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(54) **MOTOR AND ELECTRONIC APPARATUS USING THE SAME**

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(51) **Int. Cl.**
H02K 1/00 (2006.01)

(52) **U.S. Cl.** .... **310/216.111**; 310/68 B; 310/216.097; 310/216.074

(58) **Field of Classification Search** .... 310/68 B, 310/156.01, 156.05, 156.06, 216.111, 216.097, 310/216.091, 216.064, 216.074
See application file for complete search history.

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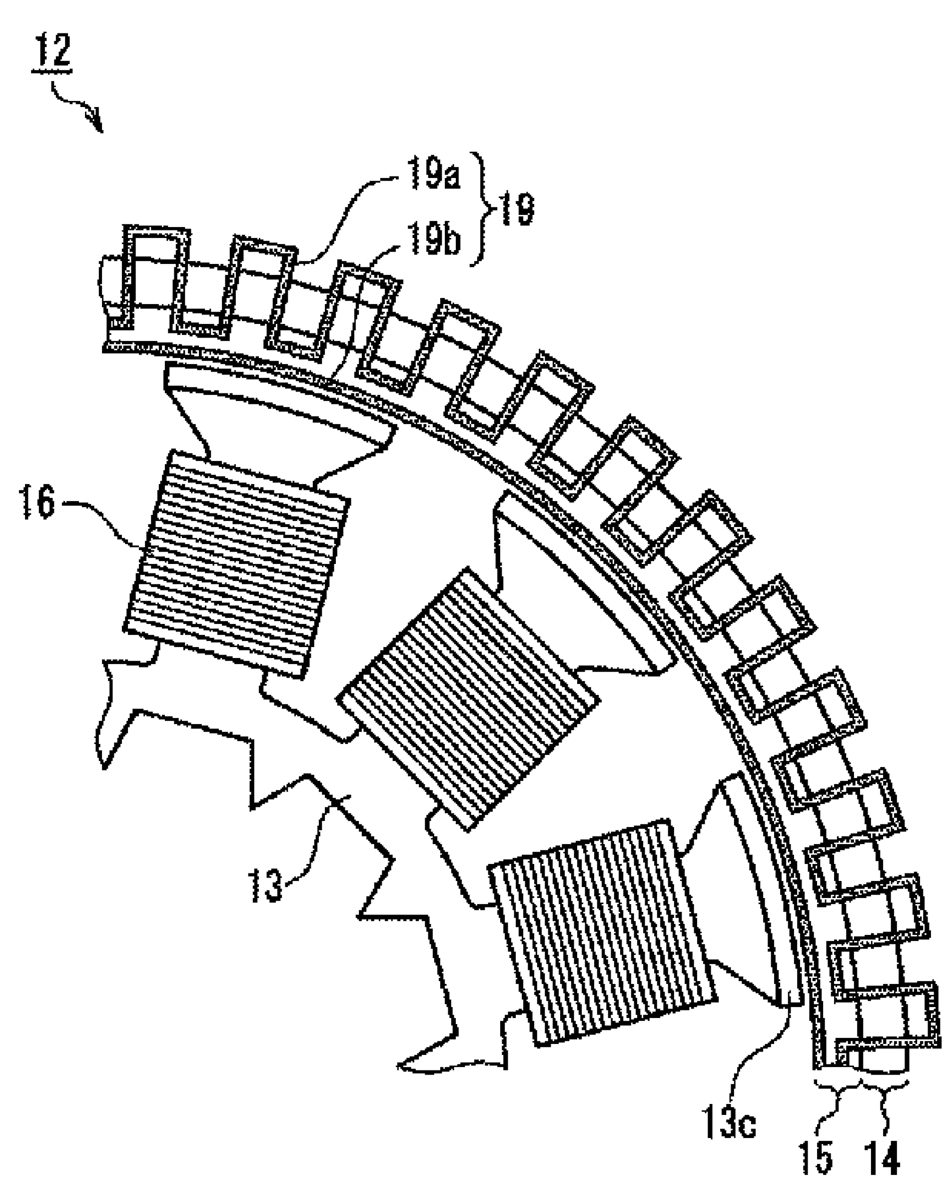
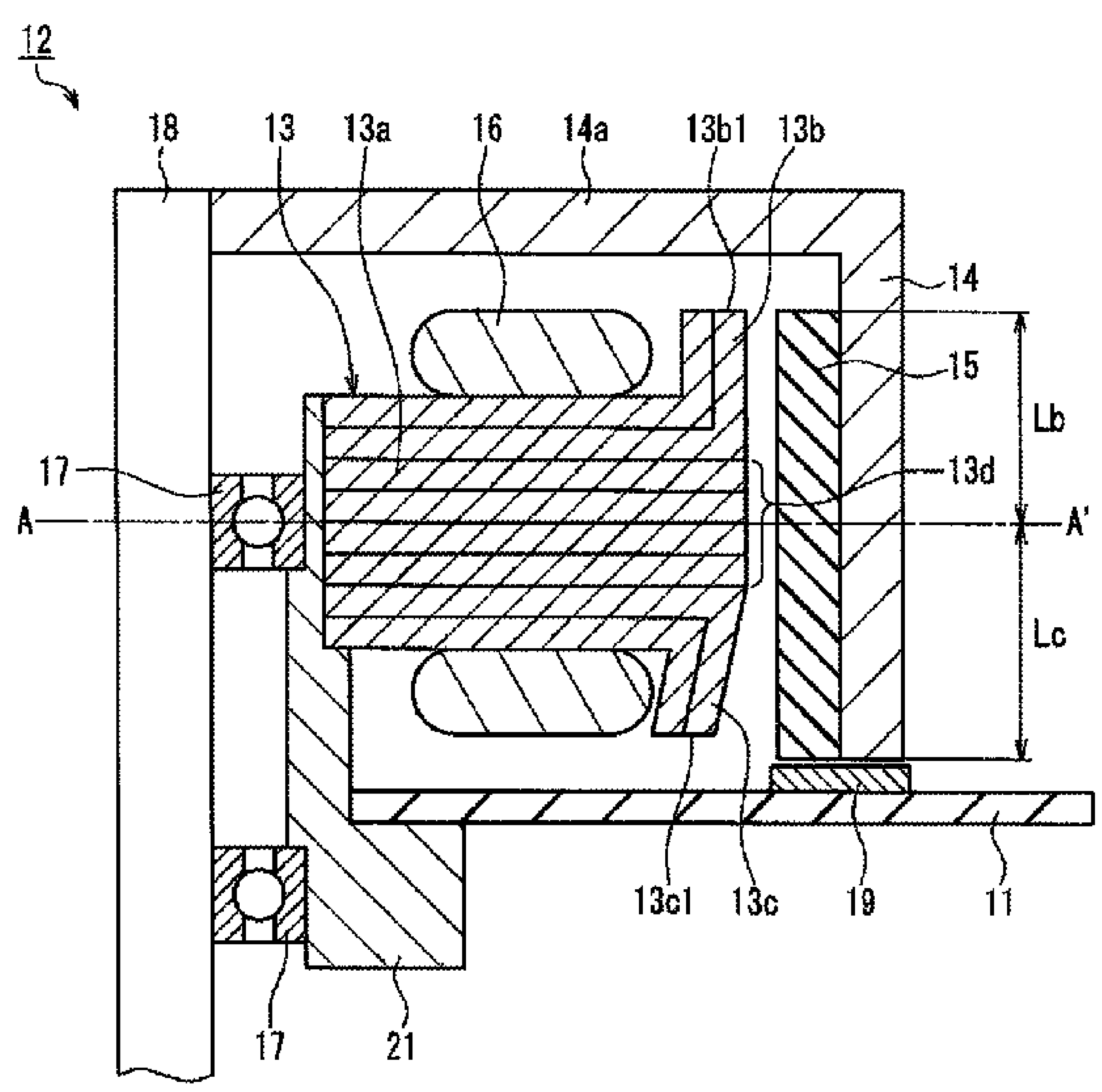
(57) **ABSTRACT**

A stator **13** on whose outer circumference a plurality of magnetic poles **13***a* are arranged is mounted on a substrate **11**, and a rotor **14** is rotatably disposed around the stator. The inner circumferential face of the rotor is provided with a magnet **15** magnetized to have alternately opposite polarities in a direction opposing the stator, and magnetized to have alternately opposite polarities in a direction opposing the substrate. The outer circumferential ends of the magnetic poles of the stator are provided with a first extended portion **13***c* that extends from a magnetic pole base **13***d* to the substrate side, and a second extended portion **13***b* that extends from the magnetic pole base to a side opposite the substrate side. A face of the substrate opposing the rotor is provided with a FG pattern **19** outside the outer circumferential face of the stator such that the FG pattern opposes the magnet. Accordingly, it is possible to improve the precision in detecting the rotational speed by reducing noise superimposed on the FG signal, while securing a high driving efficiency.

8 Claims, 12 Drawing Sheets





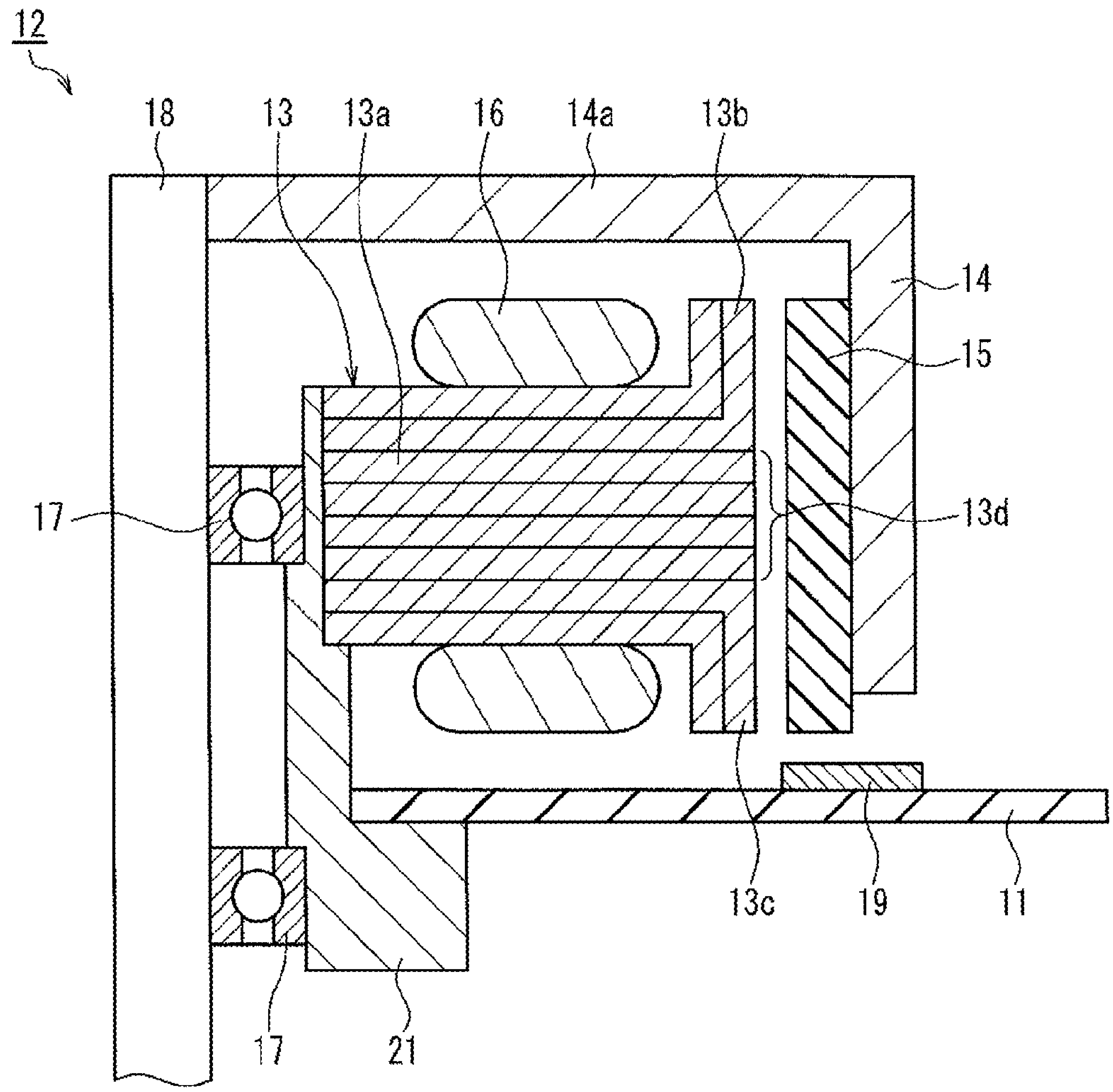


FIG. 1

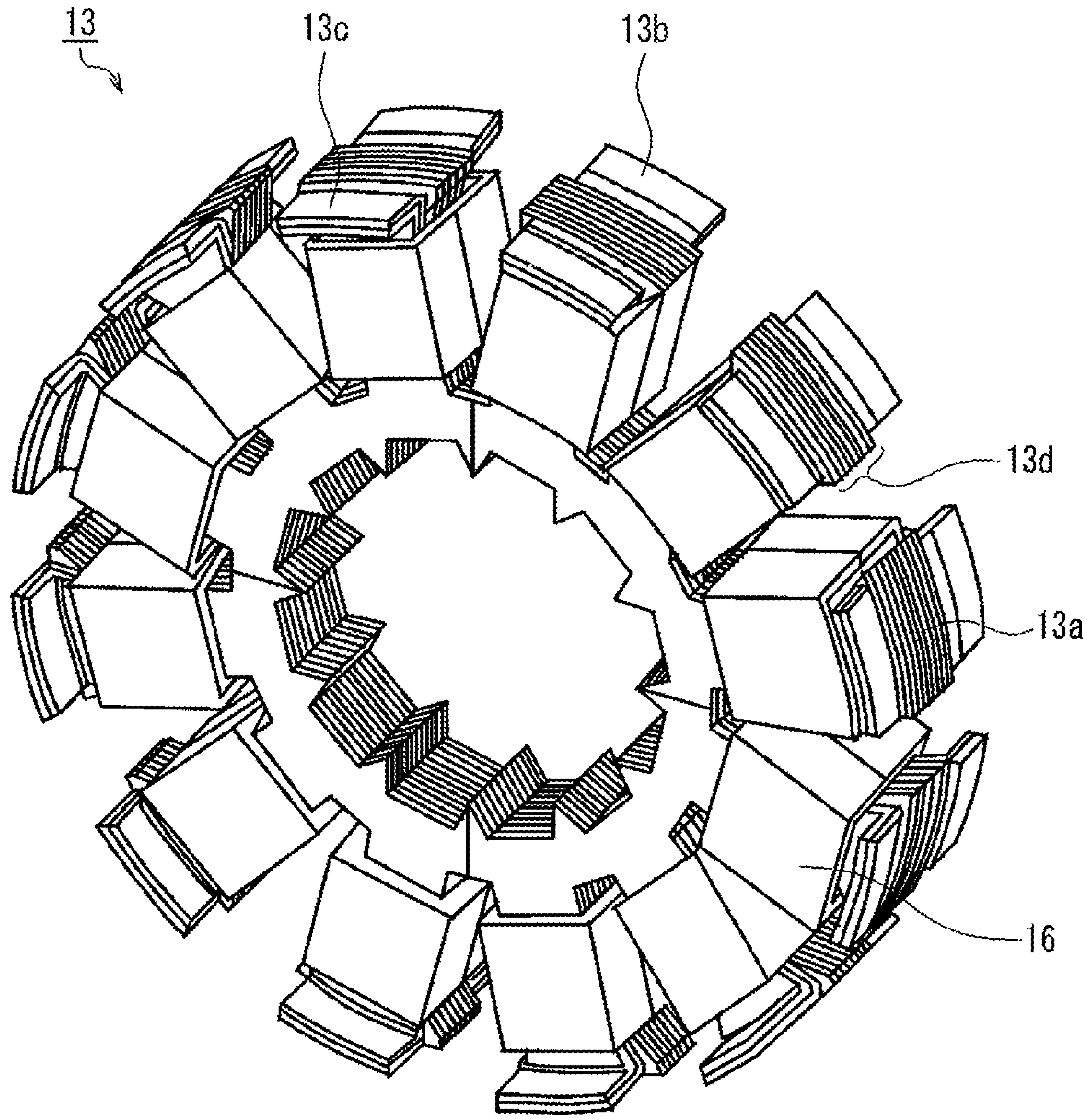


FIG. 2

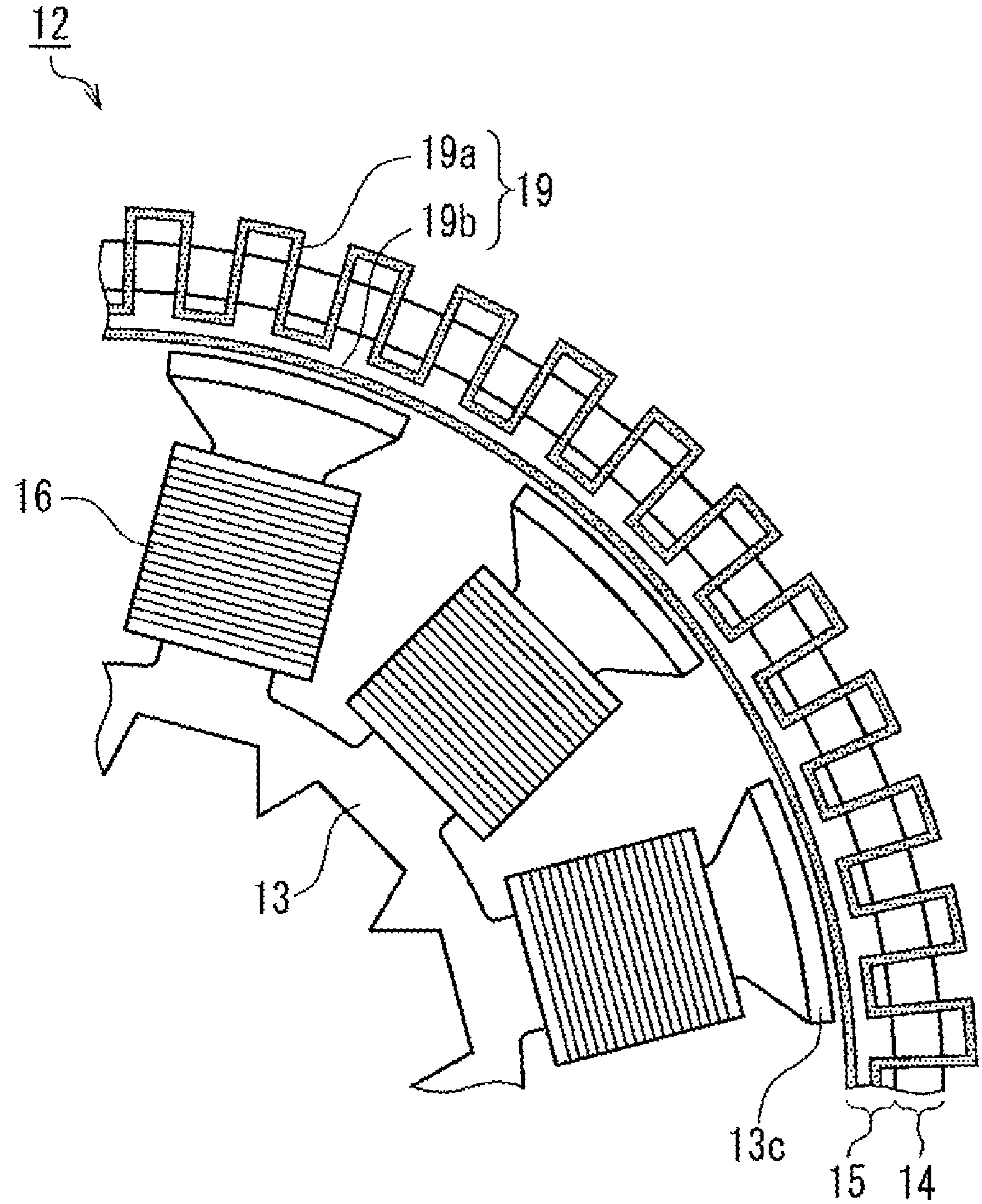


FIG. 3

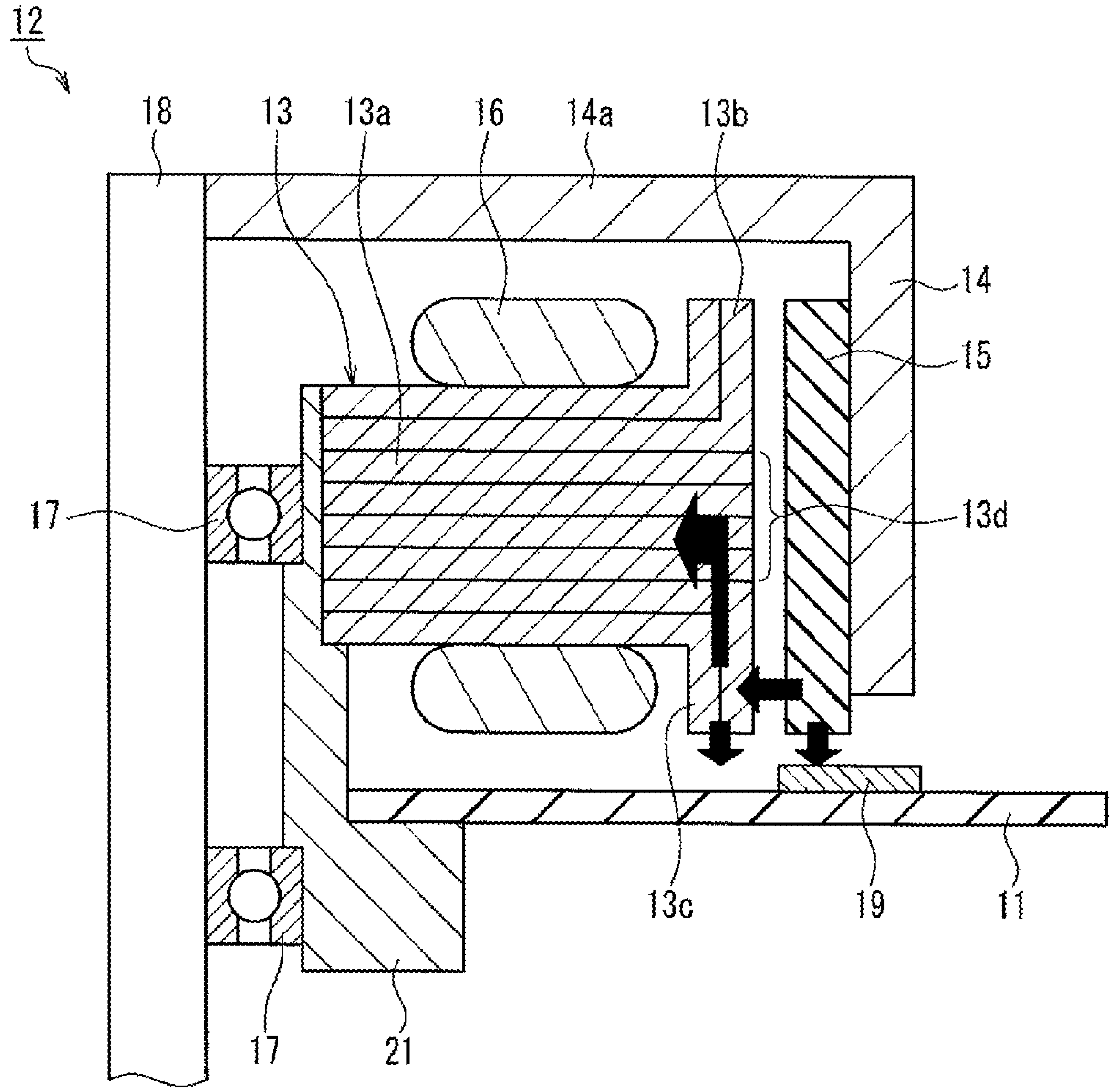


FIG. 4

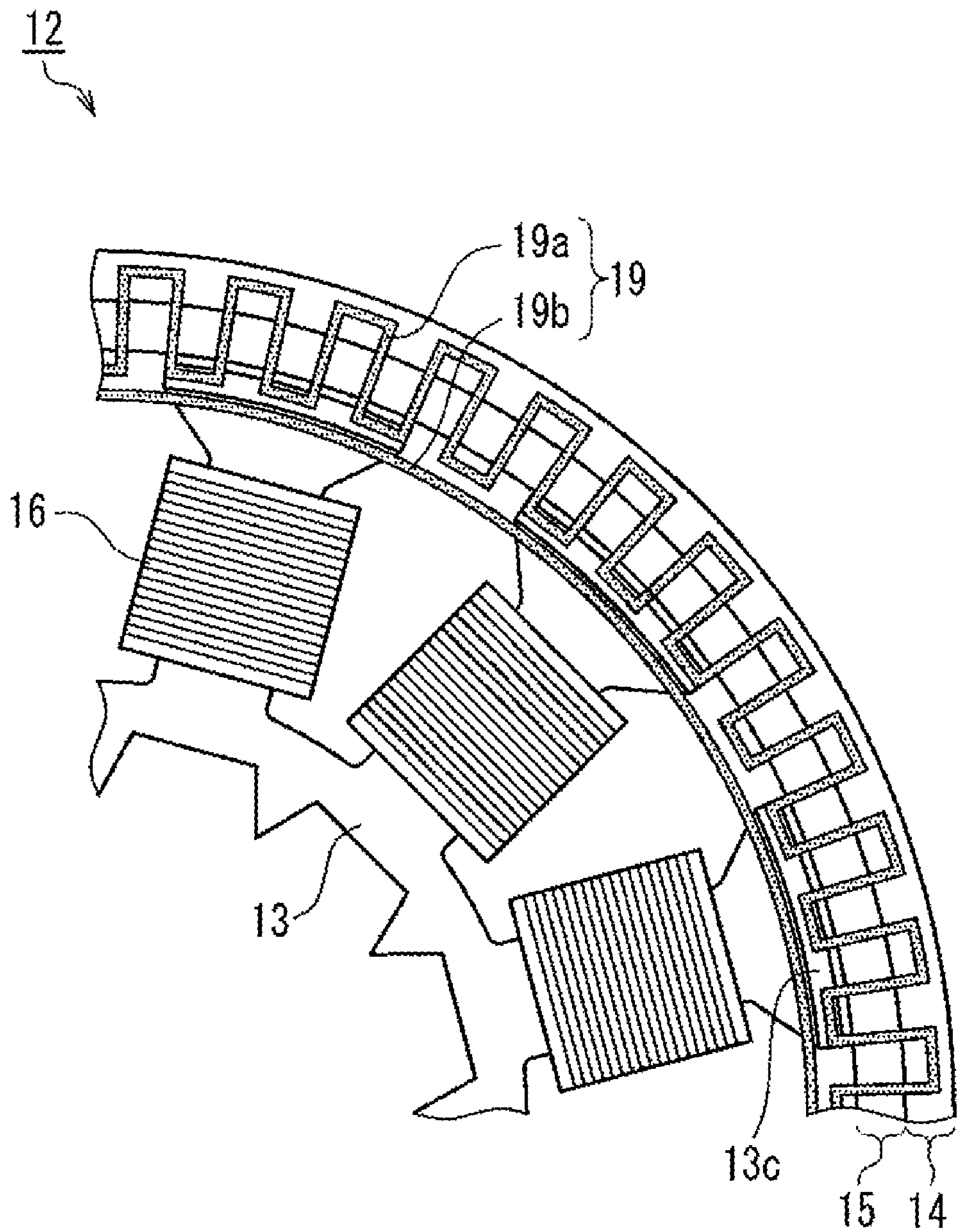


FIG. 5
PRIOR ART

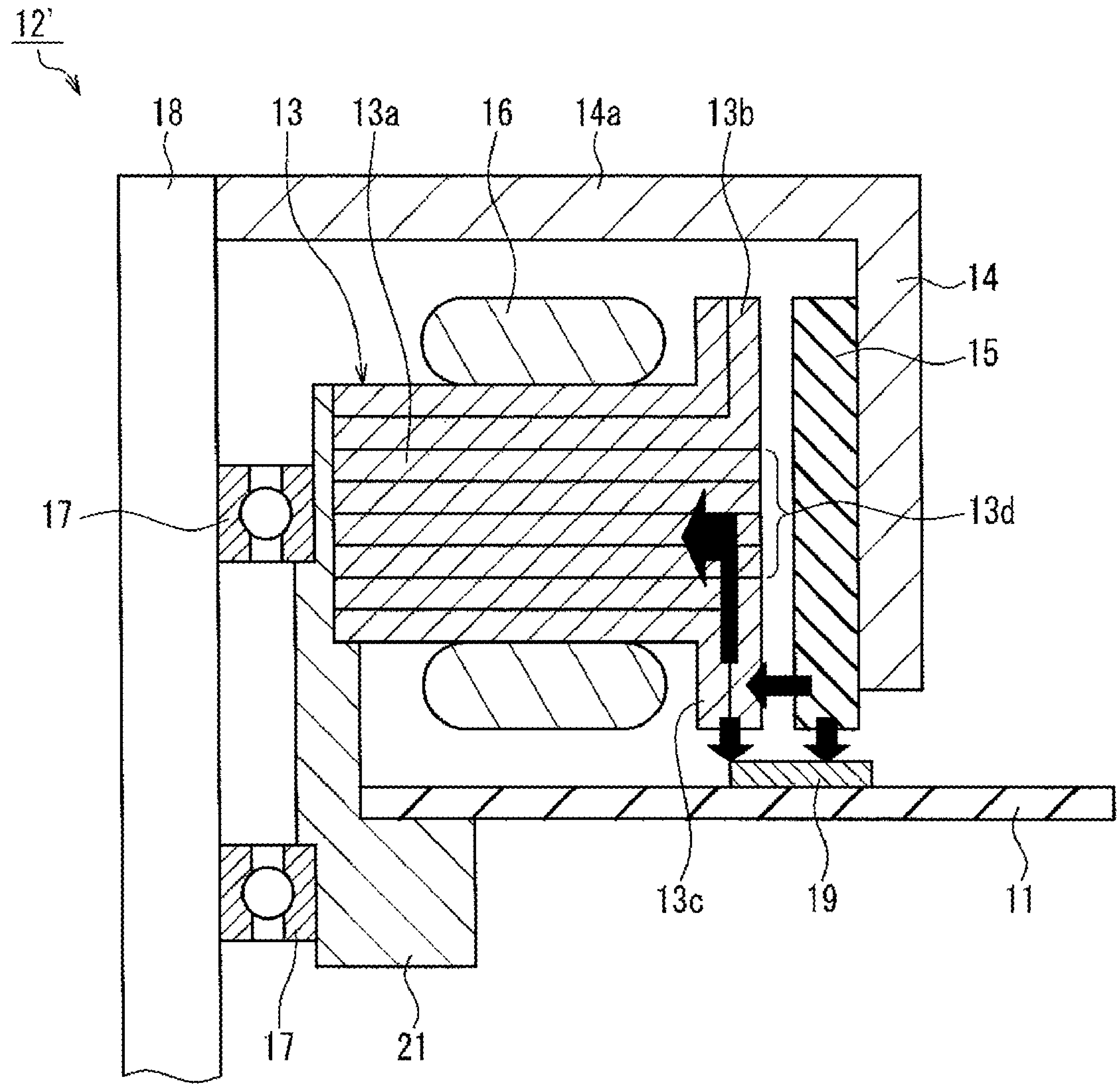


FIG. 6
PRIOR ART

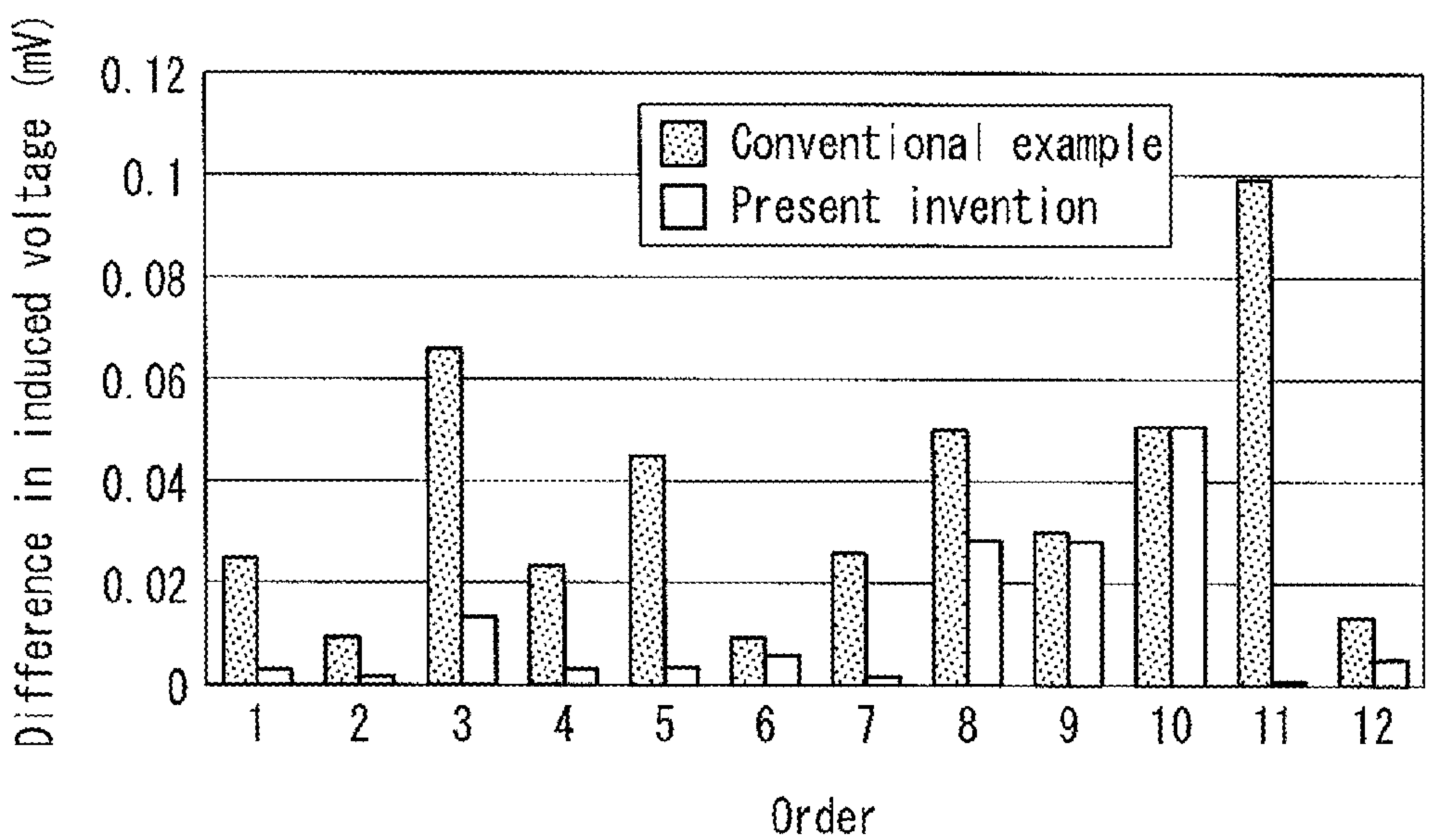

Difference in induced voltage (mV)
0.12
0.1
0.08
0.06
0.04
0.02
0
Conventional example
Present invention
1
2
3
4
5
6
7
8
9
10
11
12
Order

FIG. 7

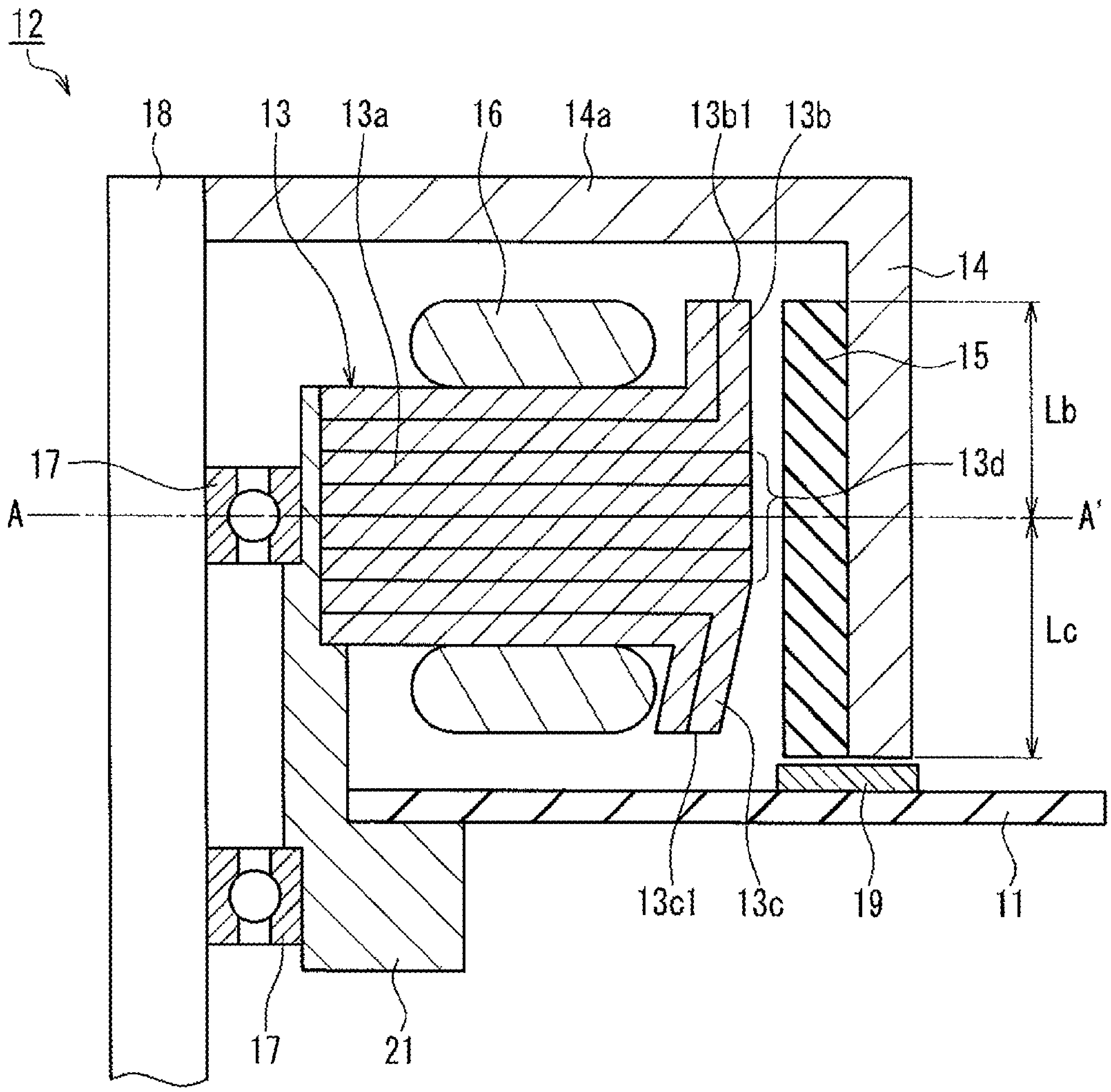
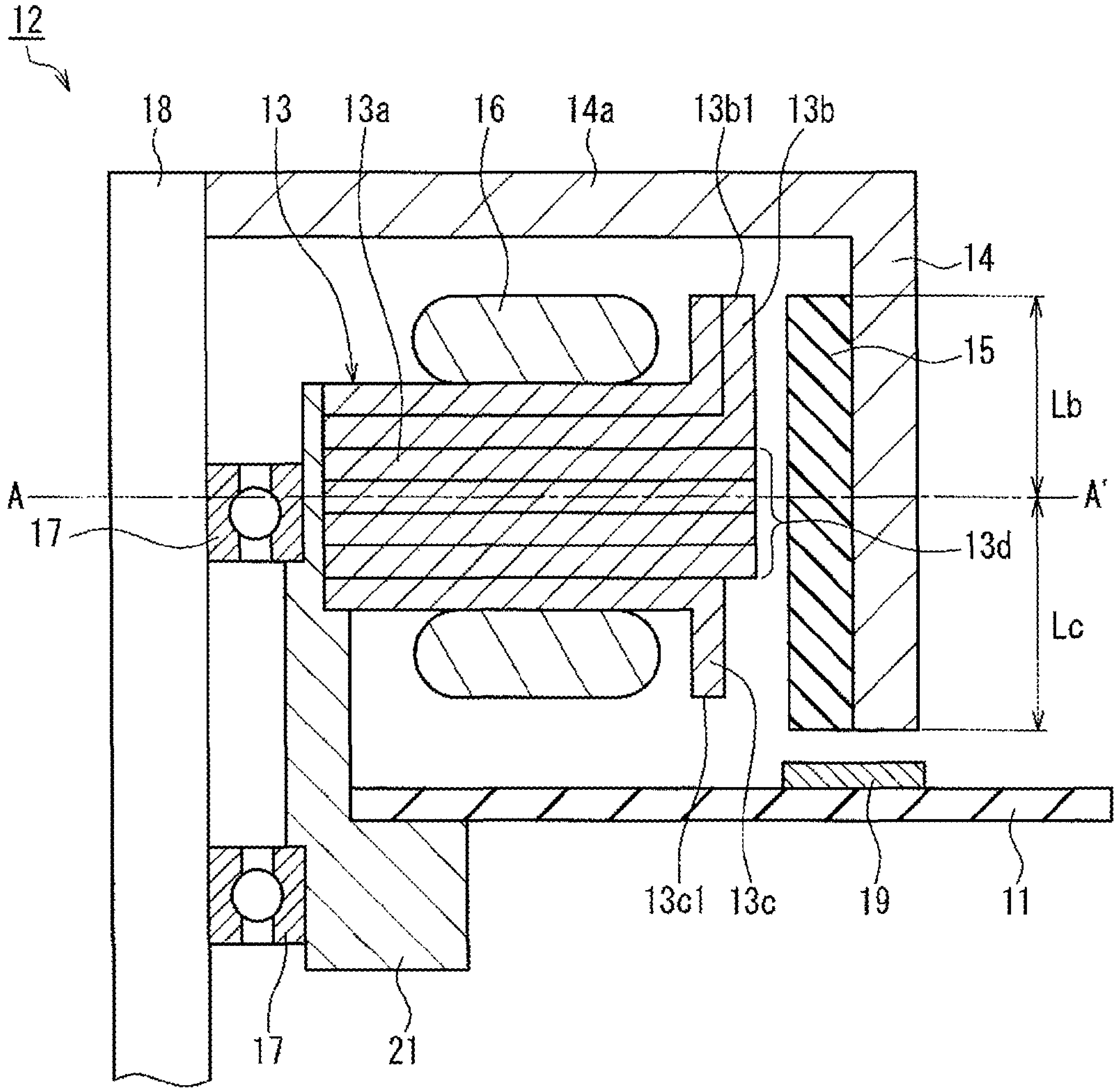

12
18
13
13a
16
14a
13b1
13b
14
15
Lb
17
13d
A
A'
Lc
13c1
13c
19
11
17
21

FIG. 8


12
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13b1
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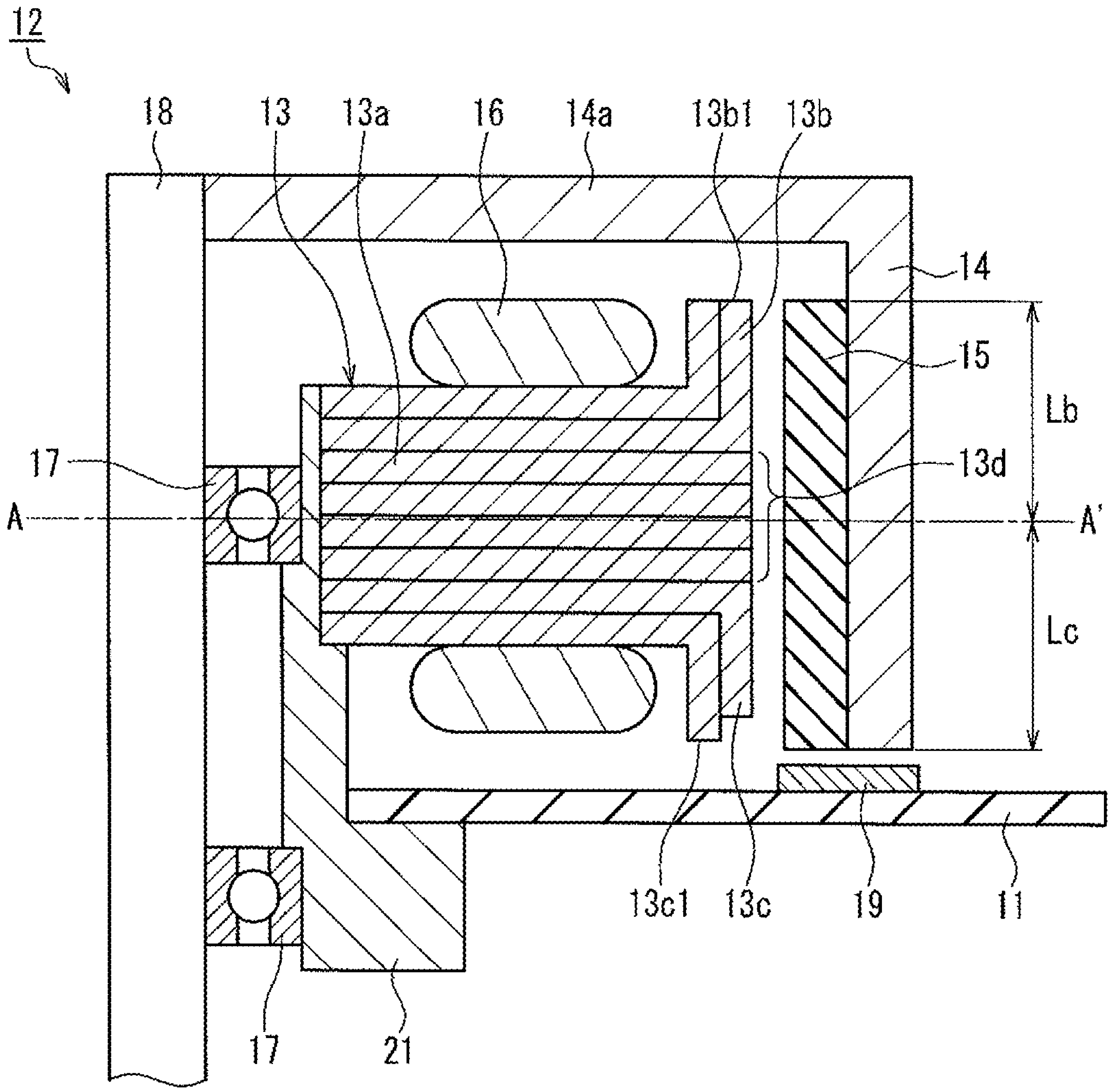
21

FIG. 9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13c
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11
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FIG. 10

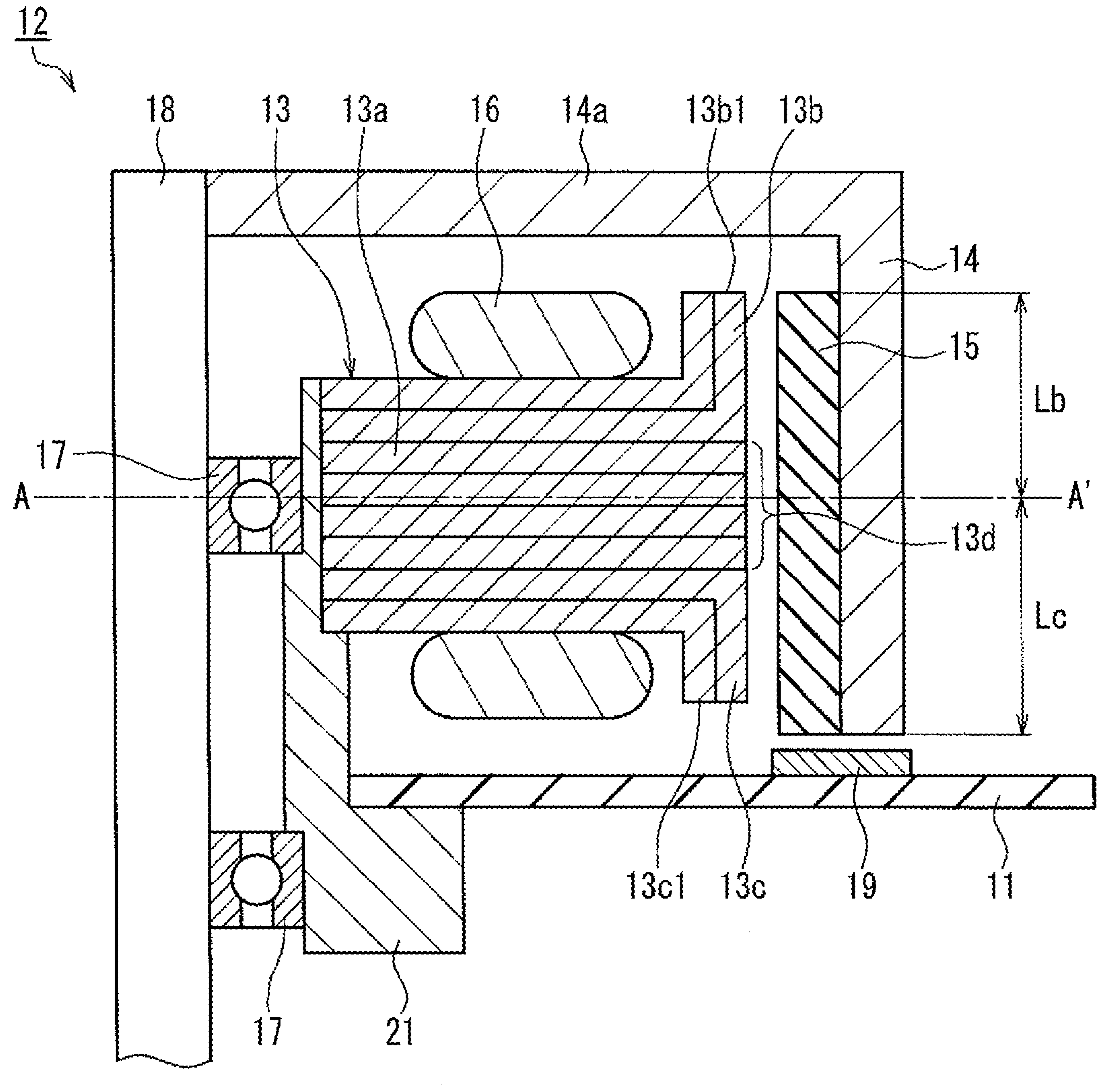
12
18
13
13a
16
14a
13b1
13b
14
15
Lb
17
A
A'
13d
Lc
13c1
13c
19
11
17
21

FIG. 11

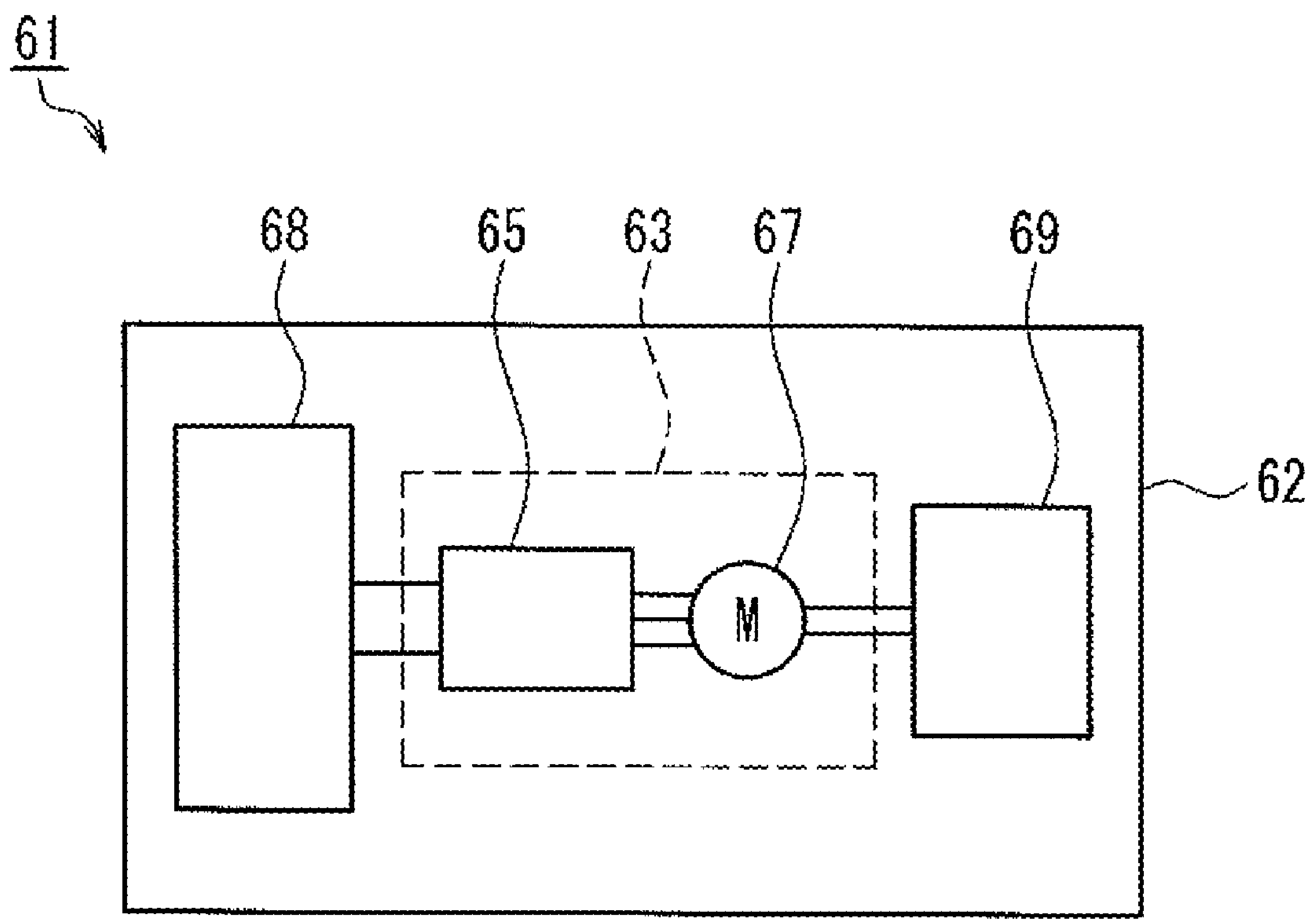

FIG. 12

MOTOR AND ELECTRONIC APPARATUS USING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a motor and an electronic apparatus using the same.

2. Description of the Related Art

In electronic apparatuses such as laser printers, a paper feed roller (driven member) provided in a main body case is coupled via a deceleration mechanism to a driving shaft of a motor. When this motor is driven, the paper feed roller rotates and feeds paper to a predetermined portion.

As this motor, a brushless DC motor that ordinarily is used includes: a stator on whose outer circumference a plurality of magnetic poles are arranged at a first predetermined interval; and a rotor that is rotatably disposed around the stator; wherein an inner circumferential face of the rotor is provided with a magnet magnetized to have opposite polarities at a second predetermined interval (main magnetization).

In this sort of motor, ordinarily in order to arrange the magnet of the rotor as close as possible to a magnetism-detecting element that magnetically detects rotation of the rotor, the size of the magnet in a direction parallel to a motor-driving shaft is set larger than the size of a magnetic pole base of the stator in the same direction. In this case, an extended portion, called an “end plate”, that extends in a direction substantially parallel to the magnet often is formed on both sides of a magnetic pole base, at outer circumferential ends of the magnetic poles of the stator (see JP H9-285044A and JP 2007-244004A, for example). Accordingly, the area in which the magnet of the rotor and the magnetic poles of the stator oppose each other increases, and, thus, the driving force and the driving efficiency of the motor can be increased.

Furthermore, for example, in the case where a paper feed roller of a laser printer is driven via a deceleration mechanism, the rotation of a brushless DC motor has to be controlled precisely. Accordingly the rotational speed of the brushless DC motor has to be detected at a certain level of resolution.

As a speed-detecting method appropriate for this sort of purpose, a FG method (described later) ordinarily is used. That is to say, the magnet of the rotor is magnetized to generate a torque (main magnetization), and, moreover, multi-pole magnetization (FG magnetization) in a direction opposing the substrate is performed on a face of the magnet opposing a substrate. Furthermore, the substrate is provided with a FG pattern in the circumferential direction, in which linear elements in the same number as that of magnetized poles of the FG magnetization are connected in series. When the rotor rotates, an induced voltage is generated at the linear elements due to magnetic fluxes obtained by the FG magnetization, and a speed detection signal (FG signal) at a frequency proportional to the rotations of the motor can be obtained through this FG pattern.

In this sort of FG method, in order to reduce the influence of the main magnetization, there is a known method for canceling the influence of the main magnetization, by configuring the FG pattern from a main pattern and a cancellation pattern and connecting the main pattern and the cancellation pattern in series (see JP 2006-25537A, for example).

However, in the case where an extended portion that extends in a direction substantially parallel to the magnet is provided at outer circumferential ends of the magnetic poles of the stator, it may be difficult to cancel the influence of magnetic fluxes obtained by the main magnetization in the above-described FG method. The reason is as follows. The extended portion provided at the outer circumferential ends of the magnetic poles has a magnetism collecting effect, and, thus, magnetic fluxes obtained by the main magnetization are drawn easily into the extended portion. Accordingly, in the radial direction, the influence of the main magnetization on a portion of the FG pattern close to the stator is different from the influence of the main magnetization on a portion away from the stator, and the influence of magnetic fluxes obtained by the main magnetization cannot be canceled sufficiently. As a result, noise is superimposed on the FG signal, and the precision in detecting the rotational speed is lowered.

SUMMARY OF THE INVENTION

It is an object of the present invention to solve the above-described conventional problem, by improving the precision in detecting the rotational speed by reducing noise superimposed on the FG signal, while securing a high driving efficiency in a motor in which extended portions are provided at outer circumferential ends of magnetic poles of a stator.

The present invention is directed to a motor, including: a stator that is mounted on a substrate and on whose outer circumference a plurality of magnetic poles are arranged at a first predetermined interval; and a rotor that is rotatably disposed around the stator. The inner circumferential face of the rotor is provided with a magnet magnetized to have opposite polarities at a second predetermined interval in a direction opposing the stator, and magnetized to have opposite polarities at a third predetermined interval in a direction opposing the substrate. Each of the outer circumferential ends of the plurality of magnetic poles of the stator is provided with a first extended portion that extends from a magnetic pole base to the substrate side, and a second extended portion that extends from the magnetic pole base to a side opposite the substrate side. A face of the substrate opposing the rotor is provided with a FG pattern including a main pattern and a cancellation pattern outside the outer circumferential face of the stator such that the FG pattern opposes the magnet.

The present invention is directed to an electronic apparatus, including: a main body case; a driven member that is provided in the main body case; and a motor that is coupled to the driven member; wherein the motor is the motor according to the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view showing the schematic configuration of a motor according to Embodiment 1 of the present invention.

FIG. **2** is a perspective view of a stator constituting the motor according to Embodiment 1 of the present invention.

FIG. **3** is a plan view of a FG pattern provided in the motor according to Embodiment 1 of the present invention.

FIG. **4** is a cross-sectional view showing simplified flows of magnetic fluxes near the FG pattern in the motor according to Embodiment 1 of the present invention.

FIG. **5** is a plan view of a FG pattern provided in a conventional motor.

FIG. **6** is a cross-sectional view showing simplified flows of magnetic fluxes near the FG pattern in the conventional motor.

FIG. **7** is a graph showing the influence of magnetic fluxes obtained by the main magnetization on a main pattern and a cancellation pattern constituting the FG pattern in the motor according to Embodiment 1 of the present invention and the conventional motor, which is obtained using a magnetic field analysis.

FIG. **8** is a cross-sectional view showing the schematic configuration of a motor according to Embodiment 2 of the present invention.

FIG. **9** is a cross-sectional view showing the schematic configuration of a motor according to Embodiment 3 of the present invention.

FIG. **10** is a cross-sectional view showing the schematic configuration of a motor according to Embodiment 4 of the present invention.

FIG. **11** is a cross-sectional view showing the schematic configuration of a motor according to Embodiment 5 of the present invention.

FIG. **12** is a diagram showing the schematic configuration of an example of an electronic apparatus using the motor of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the motor of the present invention, outer circumferential ends of the magnetic poles of the stator have the first and the second extended portions, and, thus, a magnetism collecting effect can be improved, and a high driving efficiency can be realized.

Furthermore, a face of the substrate opposing the rotor is provided with a FG pattern outside the outer circumferential face of the stator such that the FG pattern opposes the magnet, and, thus, leakage magnetic fluxes formed by magnetic fluxes obtained by the main magnetization leaking out of the first extended portion hardly are linked to the FG pattern. Accordingly, noise superimposed on the FG signal is reduced, and the precision in detecting the rotational speed using the FG pattern can be improved.

The electronic apparatus of the present invention drives a driven member using the above-described motor of the present invention and thus can drive the driven member efficiently and precisely.

In the motor of the present invention, it is preferable that a distance from a tip end of the first extended portion to the magnet is larger than a distance from a tip end of the second extended portion to the magnet. Accordingly, the distance between the tip end of the first extended portion and the FG pattern is increased further. Accordingly the phenomenon that leakage magnetic fluxes formed by magnetic fluxes obtained by the main magnetization leaking out of the first extended portion are linked to the FG pattern can be reduced further. Accordingly, the precision in detecting the rotational speed using the FG pattern can be improved further.

In the description above, the first extended portion may be inclined such that a distance to the magnet increases as the tip end of the first extended portion is approached. Alternatively, the number of layers of plate-shaped members constituting the first extended portion may be smaller than the number of layers of plate-shaped members constituting the second extended portion. Alternatively, the first extended portion may be configured from a plurality of plate-shaped members, and the plurality of plate-shaped members may have a height from the magnetic pole base that increases as the distance from the magnet increases. Accordingly, the distance from the tip end of the first extended portion to the magnet can be increased with a simple configuration, and, thus, the tip end of the first extended portion can be positioned away from the FG pattern.

In the motor of the present invention, a height of the first extended portion from the magnetic pole base may be lower than a height of the second extended portion from the magnetic pole base. Also in this case, the tip end of the first extended portion can be positioned away from the FG pattern with a simple configuration.

In the description above, it is preferable that an end portion of the magnet on the substrate side is projected further toward the substrate side than is a tip end of the first extended portion. Accordingly, displacement of the magnetic center caused because the first extended portion and the second extended portion are asymmetrical can be corrected. Thus, deterioration of precision in rotation or generation of noise and vibration can be suppressed.

Hereinafter, the present invention will be described using preferred embodiments. Here, it will be appreciated that the present invention is not limited to the following embodiments.

Embodiment 1

FIG. **1** is a cross-sectional view showing the schematic configuration of a motor **12** according to Embodiment 1 of the present invention. The cross-sectional view of the motor is substantially symmetrical with respect to a driving shaft **18**, and, thus, FIG. **1** shows only a half portion with respect to the driving shaft **18**. FIG. **2** is a perspective view of a stator **13** constituting the motor **12** according to Embodiment 1. FIG. **3** is a plan view of a FG pattern **19** provided in the motor **12** according to Embodiment 1. FIG. **3** shows only a first quadrant of the FG pattern **19**.

In the description below, the direction of the driving shaft **18** of the motor **12** is taken as a vertical direction, and the upper side and the lower side in the section of the diagram of FIG. **1** are referred to respectively as an "upper side" and a "lower side" of the motor **12**.

As shown in FIG. **1**, the motor **12** of Embodiment 1 includes the stator **13** that is mounted on a wiring board (substrate) **11** via an attachment portion **21**, and a rotor **14** that is disposed around the stator **13**. The rotor **14** is in the shape of a cylinder. The upper end thereof has a top plate **14***a* fixed thereto, and the lower end thereof is open. The inner circumferential face of the attachment portion **21** is provided with bearings **17**. The driving shaft **18** of the motor **12** passes through the bearings **17**, and the upper end of the driving shaft **18** is fixed to the top plate **14***a* of the rotor **14**. As a result, the rotor **14** and the driving shaft **18** are freely rotatable with respect to the stator **13** via the bearings **17**. A magnet **15** in the shape of a ring is fixed to the inner circumferential face of the rotor **14**. A face of the magnet **15** opposing the stator **13** is magnetized (main magnetization) such that an N-pole and an S-pole are formed alternately (such that adjacent poles have opposite polarities) at a predetermined interval in a direction opposing the stator **13** (radial direction). Furthermore, in addition to the main magnetization, multi-pole magnetization (FG magnetization) such that an N-pole and an S-pole are alternately formed at a predetermined interval in a direction opposing the wiring board **11** (vertical direction) is performed on a face of the magnet **15** opposing the wiring board **11**.

The stator **13** may be a layered member in which a plurality of plate-shaped members having the same thickness (e.g., thin steel plates having a high magnetic permeability) are layered. As shown in FIG. **2**, a plurality of magnetic poles **13***a* are arranged at a predetermined interval in the circumferential direction on the outer circumference of the stator **13**. A coil **16** for an electromagnet is wound about a portion where a magnetic circuit is formed on the inner side of each magnetic pole **13***a*. When an AC power is applied to the coil **16**, each magnetic pole **13***a* is magnetized to have an N-polarity and an S-polarity alternately. Accordingly, attraction or repulsion is generated between the magnetic pole **13***a* and the magnet **15** opposing each other, the rotor **14** rotates about the driving shaft **18**, and a rotational driving force is output via the driving shaft **18**.

The wiring board **11** is provided with the FG pattern **19**. As shown in FIG. **3**, in order to reduce the influence of the main magnetization, the FG pattern **19** is configured from a zigzag main pattern **19***a* and a circular cancellation pattern **19***b*, and the main pattern **19***a* and the cancellation pattern **19***b* are connected in series. Here, the configuration of the main pattern **19***a* and the cancellation pattern **19***b* is not limited to that in FIG. **3**, and configurations other than the above can be applied. Furthermore, the main pattern **19***a* may be provided inside the cancellation pattern **19***b* (on the driving shaft **18** side).

As the amount of magnetic fluxes obtained by the FG magnetization of the magnet **15** linked to the FG pattern **19** increases, the S/N ratio of a FG signal output from the FG pattern **19** is improved. Accordingly, in the present invention, as shown in FIG. **1**, the FG pattern **19** is disposed so as to oppose the magnet **15**, on the upper face (face opposing the rotor **14**) of the wiring board **11**. Furthermore, in order to arrange the magnet **15** and the FG pattern **19** as close to each other as possible, the lower end of the magnet **15** (the end portion on the wiring board **11** side) is extended to be near the wiring board **11**.

As a result, the vertical size of the magnet **15** increases. In accordance with this increase, the outer circumferential end of each magnetic pole **13***a* of the stator **13** is provided with a first extended portion **13***c* that extends from a central magnetic pole base **13***d* to the wiring board **11** side, and a second extended portion **13***b* that extends from the magnetic pole base **13***d* to the side opposite the wiring board **11** side (on the top plate **14***a* side). The first extended portion **13***c* and the second extended portion **13***b* are substantially parallel to the magnet **15**, that is, parallel to the axial direction of the driving shaft **18**. More specifically, the first extended portion **13***c* is formed by bending outer circumferential portions of two lower layers, including the lowermost layer, of a plurality of layers of plate-shaped members constituting the stator **13** downward at a substantially right angle, and the second extended portion **13***b* is formed by bending outer circumferential portions of two upper layers, including the uppermost layer, of the plurality of layers of plate-shaped members constituting the stator **13** upward at a substantially right angle. Here, the number of layers of plate-shaped members constituting the first and the second extended portions **13***c* and **13***b* is not limited to two, and may be one, or three or more.

In the case where the first extended portion **13***c* and the second extended portion **13***b* are arranged vertically on the magnetic pole base **13***d* from the outer circumferential end of the magnetic pole **13***a* in this manner, the area in which the magnetic pole **13***a* and the vertically extended magnet **15** oppose each other increases as shown in FIG. **1**. The first extended portion **13***c* and the second extended portion **13***b* have a magnetism collecting effect, and, thus, magnetic fluxes obtained by the main magnetization drawn into the stator **13** increase, and the driving force and the driving efficiency of the motor **12** are improved. The first extended portion **13***c* and the second extended portion **13***b* ordinarily are referred to as end plates.

In Embodiment 1, as shown in FIGS. **1** and **3**, the FG pattern **19** is disposed on an outer side in the radial direction of the outer circumferential face of the stator **13**. The effect obtained by this configuration will be described below.

FIG. **4** is a cross-sectional view showing, as arrows, simplified flows of magnetic fluxes near the FG pattern **19** in the motor **12** according to Embodiment 1. For the sake of comparison, FIG. **5** shows a plan view of the FG pattern **19** provided in the conventional motor **12'** as in FIG. **3**. FIG. **6** is a cross-sectional view showing, as arrows, simplified flows of magnetic fluxes near the FG pattern **19** in the conventional motor **12'** shown in FIG. **5**. The conventional motor **12'** shown in FIGS. **5** and **6** is different from the motor **12** of Embodiment 1 in that the FG pattern **19** and the first extended portion **13***c* are arranged so as to be overlapped in the radial direction.

In both of the motor **12** of Embodiment 1 and the conventional motor **12'**, magnetic fluxes obtained by the main magnetization are collected to the extended portions **13***b* and **13***c* through their magnetism collecting effect. Most of the collected magnetic fluxes pass through the extended portions **13***b* and **13***c*, and extend into the magnetic pole **13***a*. However, due to magnetic saturation of the extended portions **13***b* and **13***c*, part of the magnetic fluxes leaks out of the extended portions **13***b* and **13***c*, and forms leakage magnetic fluxes. The leakage magnetic fluxes can be reduced by increasing the thickness of the extended portions **13***b* and **13***c*, but cannot be completely reduced to zero. Furthermore, since the extended portions **13***b* and **13***c* are arranged at a predetermined interval in the circumferential direction, a magnetism collecting effect on magnetic fluxes obtained by the main magnetization differs between a portion where the extended portions **13***b* and **13***c* are present and a portion where these extended portions are not present, and, thus, leakage magnetic fluxes from the extended portions **13***b* and **13***c* become non-uniform.

In the conventional motor **12'**, as shown in FIGS. **5** and **6**, part (an inner portion) of the FG pattern **19** is positioned below the first extended portion **13***c*. Accordingly the degree of influence of leakage magnetic fluxes on a portion of the FG pattern **19** close to the first extended portion **13***c* (e.g., the cancellation pattern **19***b*) is significantly different from the degree of influence of leakage magnetic fluxes on a portion away from the first extended portion **13***c* (e.g., the outer portion of the main pattern **19***a*). Accordingly, the influence of magnetic fluxes obtained by the main magnetization cannot be sufficiently canceled by the main pattern **19***a* and the cancellation pattern **19***b*, and noise is superimposed on the FG signal.

On the other hand, in the motor **12** of Embodiment 1, the FG pattern **19** is disposed on an outer side in the radial direction of the outer circumferential face of the stator **13**. Accordingly, as shown in FIG. **4**, the FG pattern **19** is away from the first extended portion **13***c*. Accordingly, the leakage magnetic fluxes from the first extended portion **13***c* are hardly linked to the FG pattern **19**. That is to say, the leakage magnetic fluxes hardly affect either a portion of the FG pattern **19** close to the first extended portion **13***c* (e.g., the cancellation pattern **19***b*) or a portion away from the first extended portion **13***c* (e.g., the outer portion of the main pattern **19***a*). Accordingly, even when the FG pattern **19** receives the influence of magnetic fluxes obtained by the main magnetization, this influence can be canceled sufficiently by the main pattern **19***a* and the cancellation pattern **19***b*. Thus, noise superimposed on the FG signal is reduced, and the precision in detecting the rotational speed using the FG pattern **19** can be improved.

In the motor **12** of Embodiment 1 and the conventional motor **12'**, the influence of magnetic fluxes obtained by the main magnetization on the main pattern **19***a* and the cancellation pattern **19***b* was confirmed using a magnetic field analysis. More specifically, a frequency analysis was performed on a difference between induced voltages generated at the main pattern **19***a* and the cancellation pattern **19***b* constituting the FG pattern **19** due to magnetic fluxes obtained by the main magnetization when the rotor **14** rotated. FIG. **7** shows the results. In FIG. **7**, the vertical axis indicates a difference between induced voltages generated at the main pattern **19***a* and the cancellation pattern **19***b*. The horizontal axis indicates an order obtained when a rotational frequency component for two poles of the magnet **15** is taken as a primary component. According to FIG. **7**, at all orders, the motor **12** of Embodiment 1 ("present invention") has a difference in the induced voltage smaller than that of the conventional motor **12'** ("conventional example"). Accordingly, in the motor **12** of Embodiment 1, the influence of magnetic fluxes obtained by the main magnetization is canceled between the main pattern **19***a* and the cancellation pattern **19***b*, and, thus, noise superimposed on the FG signal can be reduced. It was confirmed that, as a result, the rotational speed can be detected with a high precision.

Embodiment 2

FIG. **8** is a cross-sectional view showing the schematic configuration of a motor according to Embodiment 2 of the present invention. As in FIG. **1**, FIG. **8** shows only a half portion with respect to the driving shaft **18**. In FIG. **8**, the same portions as those in FIG. **1** are denoted by the same reference numerals.

In Embodiment 2, the cross-sectional shapes of the first extended portion **13***c* and the second extended portion **13***b* are asymmetrical with respect to the magnetic pole base **13***d*. In this aspect, Embodiment 2 is different from Embodiment 1 in which the cross-sectional shapes are symmetrical. More specifically, as shown in FIG. **8**, the distance (in the radial direction) from a tip end **13***c***1** (i.e., a portion that is the closest to the wiring board **11**) of the first extended portion **13***c* to the magnet **15** is larger than the distance (in the radial direction) from a tip end **13***b***1** (i.e., a portion that is the closest to the top plate **14***a*) of the second extended portion **13***b* to the magnet **15**. In order to realize this configuration, the first extended portion **13***c* is formed by bending two lower layers of a plurality of layers of plate-shaped members constituting the stator **13** at an angle larger than a right angle. The second extended portion **13***b* is formed by bending two upper layers of the plurality of layers of plate-shaped members constituting the stator **13** at a substantially right angle as in Embodiment 1.

As in Embodiment 2, in the case where the tip end **13***c***1** of the first extended portion **13***c* on the wiring board **11** side is positioned away from the magnet **15**, the distance between the tip end **13***c***1** of the first extended portion **13***c* and the FG pattern **19** increases. Accordingly the phenomenon of leakage magnetic fluxes formed by magnetic fluxes obtained by the main magnetization leaking out of the tip end **13***c***1** of the first extended portion **13***c* being linked to the FG pattern **19** can be reduced further than in Embodiment 1. Accordingly, the influence of magnetic fluxes obtained by the main magnetization can be sufficiently canceled by the main pattern **19***a* and the cancellation pattern **19***b*. Thus, noise superimposed on the FG signal is reduced, and the precision in detecting the rotational speed using the FG pattern **19** can be improved.

Here, as in Embodiment 2, in the case where the distance to the magnet **15** is made different between the first extended portion **13***c* and the second extended portion **13***b*, the magnetic center is displaced from the central position in the vertical direction of the stator **13**. Accordingly, attractions to or repulsions from the magnet **15** are asymmetrical between the upper portion and the lower portion of the stator **13**, and deterioration of precision in rotation, generation of noise and vibration, or the like may occur.

Accordingly, in Embodiment 2, the lower end of the magnet **15** (the end portion on the wiring board **11** side) is projected further toward the wiring board **11** side than the tip end **13***c***1** of the first extended portion **13***c* is. Here, the upper end of the magnet **15** (the end portion on the top plate **14***a* side) and the tip end **13***b***1** of the second extended portion **13***b* are at substantially the same position in the vertical direction. Accordingly, as shown in FIG. **8**, a distance Lc from the central line A-A' of the stator **13** in the vertical direction to the lower end of the magnet **15** is longer than the distance Lb from the central line A-A' to the upper end of the magnet **15**.

In the case where the magnet **15** overhangs further toward the wiring board **11** side than the first extended portion **13***c* is in this manner, displacement of the magnetic center caused because the amount of magnetic fluxes differs between the first extended portion **13***c* and the second extended portion **13***b* can be corrected. Accordingly deterioration of precision in rotation or generation of noise and vibration, caused because the first extended portion **13***c* and the second extended portion **13***b* are asymmetrical, can be suppressed. Here, the correction of displacement of the magnetic center can be performed, for example, by comparing differences in the amounts of magnetic fluxes at an average gap in a portion having the distance Lb above the central line A-A and at an average gap in a portion having the distance Lc below the central line A-A, using a permeance calculation.

Embodiment 2 is the same as Embodiment 1 except for the above-described aspects.

Embodiment 3

FIG. **9** is a cross-sectional view showing the schematic configuration of a motor according to Embodiment 3 of the present invention. As in FIG. **1**, FIG. **9** shows only a half portion with respect to the driving shaft **18**. In FIG. **9**, the same portions as those in FIG. **1** are denoted by the same reference numerals.

In Embodiment 3, as in Embodiment 2, the distance (in the radial direction) from the tip end **13***c***1** of the first extended portion **13***c* to the magnet **15** is larger than the distance (in the radial direction) from the tip end **13***b***1** of the second extended portion **13***b* to the magnet **15**. Here, a specific configuration for varying the distance to the magnet **15** is different from that in Embodiment 2. In Embodiment 3, as shown in FIG. **9**, the number of layers of plate-shaped members constituting the first extended portion **13***c* on the wiring board **11** side is smaller than the number of layers of plate-shaped members constituting the second extended portion **13***b* on the top plate **14***a* side of the rotor **14**.

More specifically, the first extended portion **13***c* is formed by bending one layer of plate-shaped member that is the lowermost layer of a plurality of layers of plate-shaped members constituting the stator **13** downward so as to be substantially parallel to the magnet **15**, and the second extended portion **13***b* is formed by bending two upper layers of plate-shaped members, including the uppermost layer, of the plurality of layers of plate-shaped members constituting the stator **13** upward so as to be substantially parallel to the magnet **15**. The position at which the lowermost plate-shaped member is bent and the position at which the uppermost plate-shaped member is bent substantially match in the radial direction. Here, the numbers of layers of plate-shaped members constituting the first extended portion **13***c* and the second extended portion **13***b* are not limited to those described above. For example, the first extended portion **13***c* may be configured from two layers of plate-shaped members, and the second extended portion **13***b* may be configured from three layers of plate-shaped members.

As described above, in the case where the number of layers of plate-shaped members constituting the first extended portion **13***c* is made smaller than the number of layers of plate-shaped members constituting the second extended portion **13***b*, the distance from the tip end **13***c***1** of the first extended portion **13***c* to the magnet **15** is made larger than the distance from the tip end **13***b***1** of the second extended portion **13***b* to the magnet **15** as in Embodiment 2. Accordingly, as in Embodiment 2, the distance from the tip end **13***c***1** of the first extended portion **13***c* to the FG pattern **19** increases. Accordingly, noise superimposed on the FG signal is reduced, and the precision in detecting the rotational speed using the FG pattern **19** can be improved.

Also in Embodiment 3, it is preferable as in Embodiment 2 that the lower end of the magnet **15** is projected further toward the wiring board **11** side than the tip end **13***c***1** of the first extended portion **13***c* is such that the distance Lc from the central line A-A of the stator **13** in the vertical direction to the lower end of the magnet **15** is longer than the distance Lb from the central line A-A to the upper end of the magnet **15**. Accordingly, deterioration of precision in rotation or generation of noise and vibration can be suppressed.

Embodiment 3 is the same as Embodiment 1 except for the above-described aspects.

Embodiment 4

FIG. **10** is a cross-sectional view showing the schematic configuration of a motor according to Embodiment 4 of the present invention. As in FIG. **1**, FIG. **10** shows only a half portion with respect to the driving shaft **18**. In FIG. **10**, the same portions as those in FIG. **1** are denoted by the same reference numerals.

In Embodiment 4, as in Embodiments 2 and 3, the distance (in the radial direction) from the tip end **13***c***1** of the first extended portion **13***c* to the magnet **15** is larger than the distance (in the radial direction) from the tip end **13***b***1** of the second extended portion **13***b* to the magnet **15**. Here, a specific configuration for varying the distance to the magnet **15** is different from those in Embodiments 2 and 3. In Embodiment 4, as shown in FIG. **10**, a plurality of plate-shaped members constituting the first extended portion **13***c* on the wiring board **11** side have a height (vertical distance) from the magnetic pole base **13***d* that increases as the distance from the magnet **15** increases.

More specifically, the first extended portion **13***c* is formed by bending two lower layers of plate-shaped members, including the lowermost layer, of a plurality of layers of plate-shaped members constituting the stator **13** downward so as to be substantially parallel to the magnet **15**. Here, the distance from the magnetic pole base **13***d* to the lower end of a plate-shaped member away from the magnet **15** (the lowermost plate-shaped member), of two bent layers of plate-shaped members, is longer than that to the lower end of a plate-shaped member close to the magnet. This sort of configuration can be realized, for example, simply by setting two layers of plate-shaped members constituting the first extended portion **13***c* to the same size, and bending the outer circumferential portions thereof toward the wiring board **11**. Accordingly, two layers of plate-shaped members constituting the first extended portion **13***c* can be formed in the same shape using the same mold, and, thus, the production efficiency is improved.

As in Embodiments 1 to 3, a plurality of plate-shaped members constituting the second extended portion **13***b* on the top plate **14***a* side have the same height (vertical distance) from the magnetic pole base **13***d*.

Here, the numbers of layers of plate-shaped members constituting the first extended portion **13***c* and the second extended portion **13***b* are not limited to those described above. It is sufficient that the first extended portion **13***c* is configured from a plurality of plate-shaped members, and that a plurality of plate-shaped members constituting the first extended portion **13***c* have a height from the magnetic pole base **13***d* that increases as the distance from the magnet **15** increases.

Also in Embodiment 4, as in Embodiments 2 and 3, the distance from the tip end **13***c***1** of the first extended portion **13***c* to the magnet **15** is made larger than the distance from the tip end **13***b***1** of the second extended portion **13***b* to the magnet **15**. Accordingly as in Embodiments 2 and 3, the distance from the tip end **13***c***1** of the first extended portion **13***c* to the FG pattern **19** increases. Accordingly, noise superimposed on the FG signal is reduced, and the precision in detecting the rotational speed using the FG pattern **19** can be improved.

Also in Embodiment 4, it is preferable as in Embodiments 2 and 3 that the lower end of the magnet **15** is projected further toward the wiring board **11** side than the tip end **13***c***1** of the first extended portion **13***c* is such that the distance Lc from the central line A-A of the stator **13** in the vertical direction to the lower end of the magnet **15** is longer than the distance Lb from the central line A-A' to the upper end of the magnet **15**. Accordingly, deterioration of precision in rotation or generation of noise and vibration can be suppressed.

Embodiment 4 is the same as Embodiment 1 except for the above-described aspects.

Embodiment 5

FIG. **11** is a cross-sectional view showing the schematic configuration of a motor according to Embodiment 5 of the present invention. As in FIG. **1**, FIG. **11** shows only a half portion with respect to the driving shaft **18**. In FIG. **11**, the same portions as those in FIG. **1** are denoted by the same reference numerals.

In Embodiment 5, as in Embodiments 2 to 4, the cross-sectional shapes of the first extended portion **13***c* and the second extended portion **13***b* are asymmetrical with respect to the magnetic pole base **13***d*. Here, a specific configuration for asymmetrizing the cross-sectional shapes is different from those in Embodiments 2 to 4. In Embodiment 5, as shown in FIG. **11**, the height (vertical distance) of the first extended portion **13***c* from the magnetic pole base **13***d* is lower than the height (vertical distance) of the second extended portion **13***b* from the magnetic pole base **13***d*. Also in the case where the distance between the tip end **13***c***1** of the first extended portion **13***c* and the FG pattern **19** is increased in the vertical direction as in Embodiment 5, as in Embodiments 2 to 4, the phenomenon that leakage magnetic fluxes formed by magnetic fluxes obtained by the main magnetization leaking out of the tip end **13***c***1** of the first extended portion **13***c* are linked to the FG pattern **19** can be reduced further than in Embodiment 1. Accordingly, the influence of magnetic fluxes obtained by the main magnetization can be canceled sufficiently by the main pattern **19***a* and the cancellation pattern **19***b*. Thus, noise superimposed on the FG signal is reduced, and the precision in detecting the rotational speed using the FG pattern **19** can be improved.

Also in Embodiment 5, it is preferable as in Embodiments 2 to 4 that the lower end of the magnet **15** is projected further toward the wiring board **11** side than the tip end **13***c***1** of the first extended portion **13***c* is such that the distance Lc from the central line A-A of the stator **13** in the vertical direction to the lower end of the magnet **15** is longer than the distance Lb from the central line A-A' to the upper end of the magnet **15**.

Accordingly, deterioration of precision in rotation or generation of noise and vibration can be suppressed.

Embodiment 5 is the same as Embodiment 1 except for the above-described aspects.

Two or more of Embodiments 2 to 5 described above may be combined as appropriate.

Embodiment 6

FIG. **12** is a diagram showing the schematic configuration of an example of an electronic apparatus using the motor of the present invention. In FIG. **12**, an electronic apparatus **61** includes a casing **62** that functions as a main body case, an electric motor **67** mounted inside the casing **62**, a driving unit **65** for driving the electric motor **67**, a power source **68** for supplying electricity to the driving unit **65**, and a load (driven member) **69** such as a mechanism portion that is driven using the electric motor **67** as a power source. Here, the electric motor **67** and the driving unit **65** constitute an electric motor drive apparatus **63**. The electric motor **67** is driven by electrical power supplied from the power source **68** via the driving unit **65**. A rotational torque is transmitted via the driving shaft of the electric motor **67** to the load **69**. The motor **12** of the present invention can be used as the electric motor **67**.

For example, a laser printer can be given as an example of the electronic apparatus **61**. In this case, a paper feed roller corresponds to the load **69**. The motor **12** of the present invention may be mounted together with various electronic components on the wiring board **11** that is horizontally provided in a main body case of the laser printer. In the motor **12**, a gear (not shown) can be fixed to a lower portion of the driving shaft **18** that passes through the wiring board **11** and extends downward, and this gear and a gear provided at the paper feed roller can be coupled to each other via a gearbox (not shown) functioning as a deceleration mechanism. The motor **12** of the present invention has a high driving efficiency and excellent precision in detecting the rotational speed, and, thus, paper can be sent efficiently and precisely while suppressing non-uniform rotation, noise, and the like, and a laser printer can be realized that can perform accurate printing without print position shift or the like.

According to the present invention, it is possible to provide a motor that has an improved precision in detecting the rotational speed while maintaining efficient driving. Thus, the present invention is preferable for a motor that is used in electronic apparatuses such as laser printers, laser copiers, and the like. Here, the motor of the present invention is not limited to these, and can be used widely as a motor that is required to have a highly precise rotation.

The embodiments described above are solely intended to elucidate the technological content of the present invention, and the present invention is not limited to or by these specific examples alone. Various modifications are possible within the spirit of the invention and the scope of the claims, and the present invention should be interpreted broadly.

What is claimed is:

1. A motor, comprising:

a stator that is mounted on a substrate and on whose outer circumference a plurality of magnetic poles are arranged at a first predetermined interval; and

a rotor that is rotatably disposed around the stator;

wherein an inner circumferential face of the rotor is provided with a magnet magnetized to have opposite polarities at a second predetermined interval in a direction opposing the stator, and magnetized to have opposite polarities at a third predetermined interval in a direction opposing the substrate,

each of outer circumferential ends of the plurality of magnetic poles of the stator is provided with a first extended portion that extends from a magnetic pole base to the substrate side, and a second extended portion that extends from the magnetic pole base to a side opposite the substrate side, and

a face of the substrate opposing the rotor is provided with a FG pattern including a main pattern and a cancellation pattern outside an outer circumferential face of the stator such that the FG pattern opposes the magnet.

2. The motor according to claim **1**, wherein a distance from a tip end of the first extended portion to the magnet is larger than a distance from a tip end of the second extended portion to the magnet.

3. The motor according to claim **2**, wherein the first extended portion is inclined such that a distance to the magnet increases as the tip end of the first extended portion is approached.

4. The motor according to claim **2**, wherein the number of layers of plate-shaped members constituting the first extended portion is smaller than the number of layers of plate-shaped members constituting the second extended portion.

5. The motor according to claim **2**,

wherein the first extended portion is configured from a plurality of plate-shaped members, and

the plurality of plate-shaped members have a height from the magnetic pole base that increases as the distance from the magnet increases.

6. The motor according to claim **1**, wherein a height of the first extended portion from the magnetic pole base is lower than a height of the second extended portion from the magnetic pole base.

7. The motor according to claim **2**, wherein an end portion of the magnet on the substrate side is projected further toward the substrate side than a tip end of the first extended portion is.

8. An electronic apparatus, comprising:

a main body case;

a driven member that is provided in the main body case; and

a motor that is coupled to the driven member;

wherein the motor is the motor according to claim **1**.

* * * * *